

Nuclear Reactor Accidents: Three Mile Island, Chernobyl

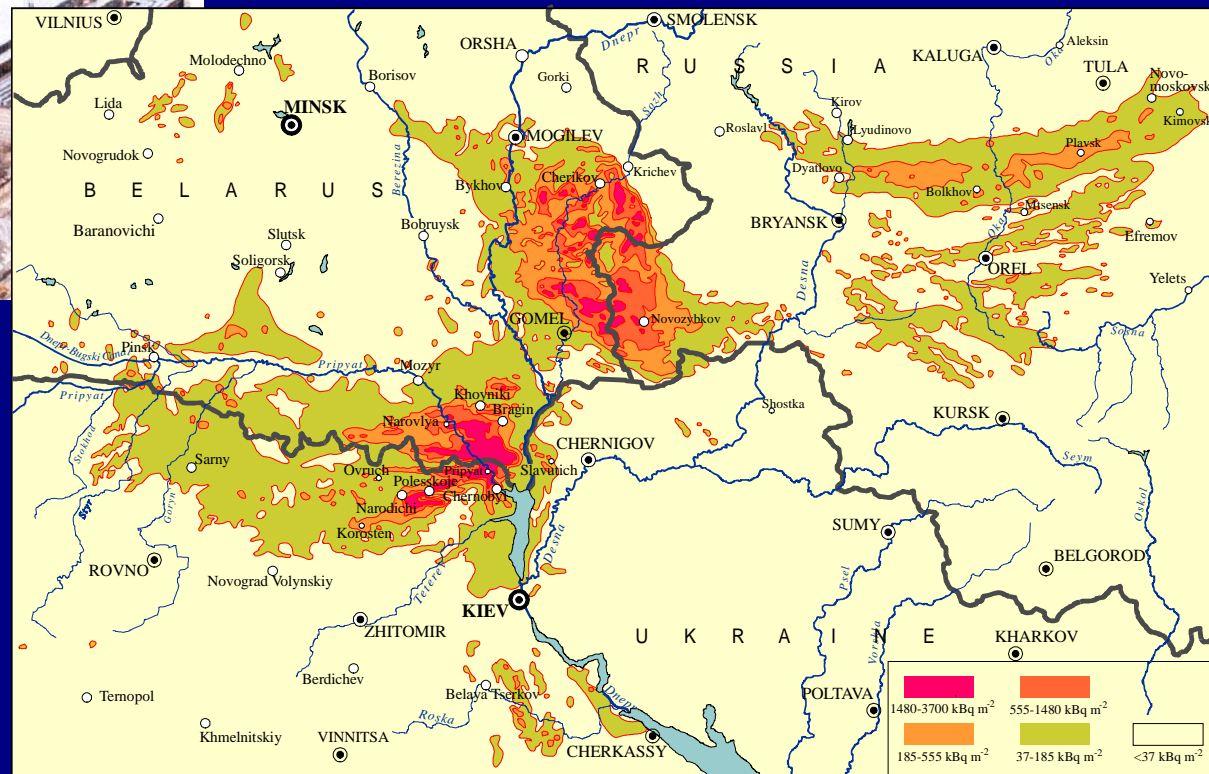
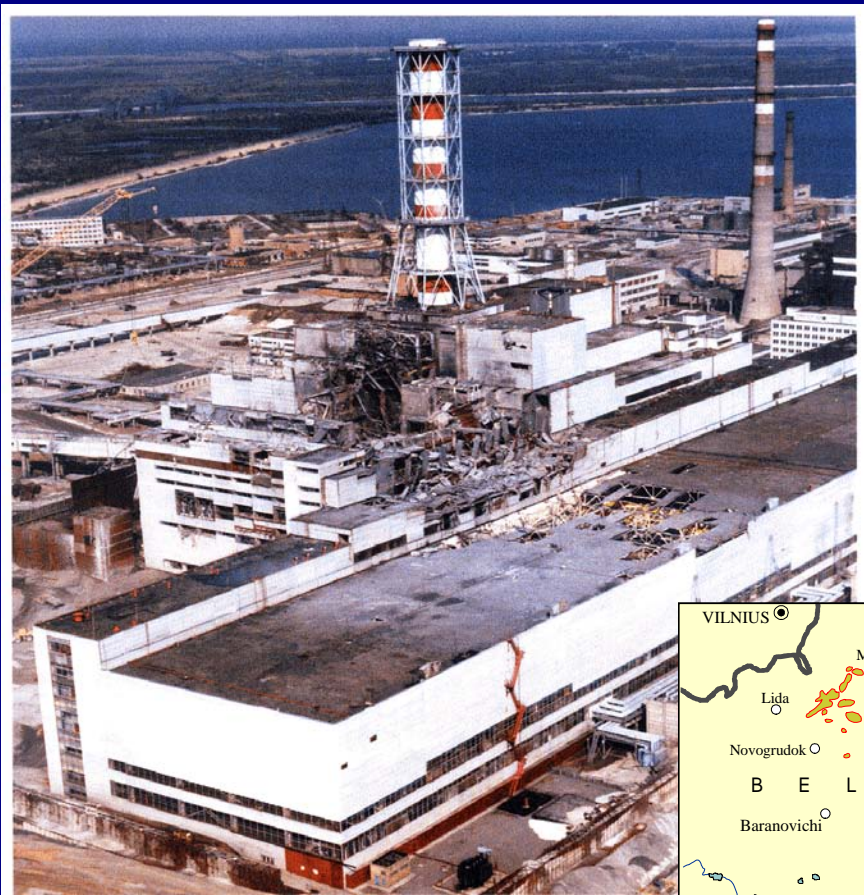
Epidemiology

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2011 Radiation Epidemiology and Dosimetry
Course

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Chernobyl





Three mile Island Cooling Tower

TMI Epidemiologic Studies

- **Columbia University** study of cancer rates within a 10 mile radius of the plant
- **PA Dept. of Health** study of cancer mortality within a 5 mile radius of the plant
- **Penn State** study of thyroid cancer incidence in three 'at-risk' counties

The Columbia Study

- **Rationale:**
 - Continuing public concern despite very low exposure
- **Design:**
 - Comparison of cancer rates through 1985 for 69 small geographic areas by dispersion-model-based estimates of radioactive emissions.
 - Focus on leukemia and childhood malignancies.

Columbia Study

- **Case ascertainment:**
 - hospital record review
- **Emissions model:**
 - Release height, temperature, wind speed and direction
 - Location and height of receptor points, terrain features
 - validated against off-site thermoluminescent dosimeters
- **Highest exposures N/NW of the plant**

Columbia Study

- **Conclusions:**

- No clear associations of estimated emissions with radiosensitive cancer types and population subgroups
- Hence, no convincing evidence that accident releases influenced cancer risk

Studies by Others

- **PA Dept. of Health SMR study (1979-1998)**
 - No impact on cancer mortality overall
 - Dose-response trends for breast cancer and lymphatic/hematopoietic cancers
(Talbot et al., Environ Health Perspec 2003)
- **Penn State Thyroid Cancer Incidence study**
 - Upward trend beginning in 1990. No cases in those exposed as children
(Levin , Laryngoscope 2008)

Cancer Near Nuclear Plants: Latest Developments

- **COMARE 14TH REPORT, 2011**
 - New geographical study in Great Britain finds no association between leukemia risk in children under 5 years of age and proximity to a nuclear power plant
- **April, 2010: NRC** requests new study around US nuclear power plants

The Chernobyl Accident

25 Years of Study

Leukemia and Thyroid Cancer Research

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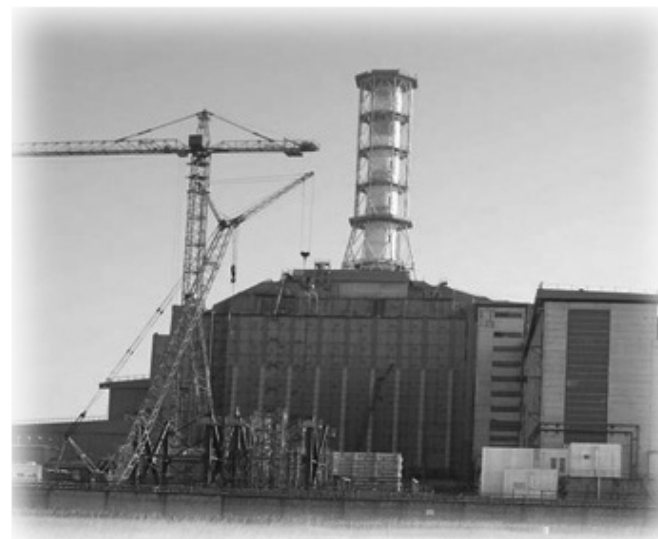
Chernobyl Nuclear Accident

On April 26, 1986 an accident occurred at the Chernobyl nuclear power plant in northern Ukraine. In addition to 28 near-term deaths due to radiation, the accident resulted in the exposure of 5 million people in Belarus, Russia and Ukraine to fallout from the accident, principally radioiodines.

This exposure has led to substantial epidemiological research, especially among clean up workers and children. Over the past 25 years, the governments of Ukraine, Belarus and the United States*, and research partners, have been conducting such research.

Explore this site further to read about our radiation epidemiology and dosimetry studies, find out what is known, and learn what we are still studying.

* Radiation Epidemiology Branch, Division of Epidemiology and Genetics, National Cancer Institute, National Institutes of Health, Department of Health and Human Services.



<http://chernobyl.cancer.gov/>

NCI Chernobyl Studies

- Leukemia Risk in Clean-up Workers
 - exposed primarily to relatively low doses of **external radiation**, which affects the bone marrow
- Thyroid Disease in the Public
 - exposed to **internal radiation**, primarily Iodine-131, a radioisotope that concentrates in the thyroid

Chernobyl clean-up workers



- Most promising group for studying effects of exposure to external radiation
- Earlier studies, based on external comparisons, suggested excess leukemia (~150 mGy)

NCI Leukemia Study

- Cohort of 110,645 registered male clean-up workers from Ukraine
- Cases from all medical facilities (1986-2000), confirmed by international experts
- Controls matched on age and area of residence

Estimated Bone Marrow Doses for Cases and Controls

	Cases	Controls
Mean (mGy)	144	67
n	71	501

Analysis of Confirmed Cases

All Leukemia	N= 71
CLL (chronic lymphocytic leukemia, thought not to be related to radiation)	N= 39
Non-CLL leukemias	N= 32

Dose-Response Results

- All Leukemias:
ERR/Gy = 3.44 (95% CI: 0.47, 9.78)
Significant linear dose-response
- CLL: ERR/Gy = 4.09 (<0, 14.41)
Significant linear dose-response
- Non-CLL: ERR/Gy = 2.73 (<0, 13.5)
Nonsignificant linear dose-response

Comparison with IARC Leukemia Case-Control Study

	Leukemias	Mean dose (mGy)	EOR/Gy
NCI	71	87	3.4 (0.5 - 9.8)
IARC	40	45	4.8 (< 0 - 33)

Romanenko et al., Radiat Res, 2008; Kesminiene et al., Radiat Res 2008;
Kryuchkov et al., Health Phys 2009

NCI / IARC Results for CLL/Non-CLL

Country (study)	EOR/Gy	
	CLL	Non-CLL
Ukraine (NCI)	4.1 (<0 to 14.4) 49 cases	2.7 (<0 to 13.5) 32 cases
Bealrus/Russia/ Baltic (IARC)	5.0 (<0 to 57) 19 cases	4.7 (<0 to 76) 21 cases

Romanenko et al., Radiat Res, 2008; Kesminiene et al., Radiat Res, 2008

NCI Study Extension

- Cases from 2001-2006 identified through the Cancer Registry of Ukraine (N = 65)
- Registry ascertainment appears to be complete
- Manuscript on combined results is in preparation

Summary of Key Findings

- Leukemia risk following low doses of external radiation at low dose rates comparable to that among atomic bomb survivors with acute exposure
- Elevated risk for CLL, consistent with IARC study

The Public:

Exposure to Radioactive Iodine

- ^{131}I concentrates in the thyroid
(thyroid dose far greater than average body dose,
dose to other organs)
- Can be inhaled and ingested (mainly in milk);
ingestion may be major pathway
- Children received the highest doses (small thyroid
mass, high milk consumption)

What Was Known Before Chernobyl

- Iodine-131: medical uses
 - No obvious increases in treated adults; data sparse in children
- X-ray exposures: medical uses
 - Increased risk following exposure in childhood

Thyroid Cancer in Ukraine: Time Trends Suggest a Problem

Year	Thyroid Cancer (No.)
1981	0
1982	0
1983	0
1984	0
1985	0
1986	0
1987	0
1988	0
1989	0
1990	3

Prisyazhiuk A, et al., The Lancet 1991

NCI Chernobyl Thyroid Studies

- **High risk populations in Ukraine (~13,000) and Belarus (~12,000):**
All subjects <18 years old at exposure, residents of contaminated areas, with measured radiation activity to the thyroid
- **Thyroid the focus:**
Cohort study with clinical screening examinations every 2 years, 1997-2007

Major Strengths of Thyroid Studies

- Prospective design: long-term follow-up
- Cancer cases confirmed by experts
- Individual measurement-based doses and dose reconstruction methods

Additional Strengths

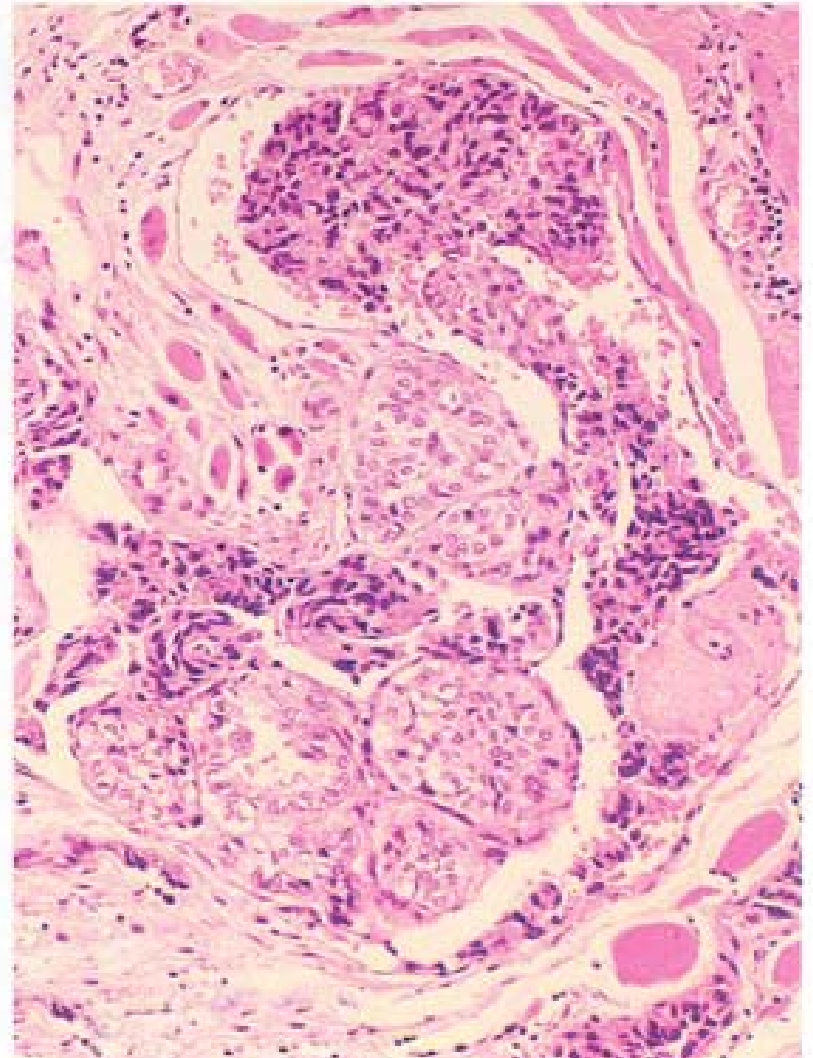
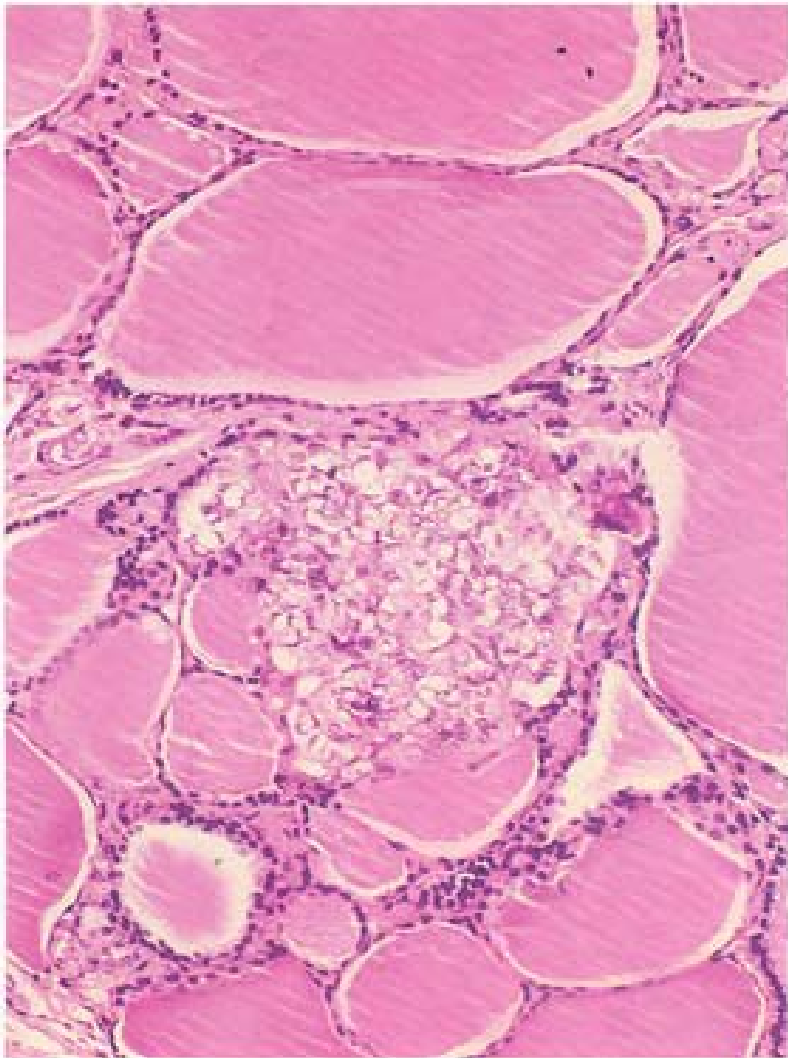
- High retention
- Good compliance with FNA, surgery
- Confirmation of cases
- Structured interviews
- Evaluation of modifying factors

Important Results to Date: Cancer Prevalence

	N	Mean dose (Gy)	EOR/Gy
Ukraine	45	0.68	5.3 (1.7 to 28)
Belarus	85	0.56	2.2 (0.8 to 5.5)

Tronko et al., JNCI, 2006; Zablotska et al., Br J Ca, 2011

Papillary Thyroid Cancer (PTC) in Ukraine: Solid subtype, Classic PTC



Most Recent Result

- Dose-response for 65 incident cancers in Ukraine identified in cycles 2-4:

$$\text{ERR/Gy} = 1.91 \text{ (0.43, 6.35)}$$

Brenner et al., Environ Health Perspec 2011

Summary of Key Findings

- Thyroid cancer risk greatest for those youngest at exposure (≥ 3 -fold higher in 0-4 year age group)
- Excess consistent with results from earlier studies of I-131 fallout and external radiation in childhood
- Risk still significantly increased 20 years after exposure

Brenner et al., Environ Health Perspec 2011

Zablotska et al., Br J Cancer 2011

Tronko et al., JNCI 2006

NCI *In Utero* Study

- 2,582 mother-child pairs
- Thyroid screenings between 2003-2006
- 7 thyroid cancers, 1 Hurthle cell neoplasm

EOR/GY=11.7 (P=0.12)

Hatch et al., JCEM, 2009; Likhtarev et al., Health Phys, 2011

Ongoing NCI Chernobyl Research

- Continued monitoring of cancer among exposed young persons using National Cancer Registries
- In Ukraine:
 - Follow-up of subjects with thyroid nodules
 - Genetic studies using materials from the NCI Chernobyl Tissue Bank
 - Pilot study of thyroid cancer in early clean-up workers exposed to I-131 as well as external radiation

Contributions of the NCI Chernobyl Research Program

- Knowledge of adverse effects of I-131
- Safe use of I-131 in clinical practice
- Methods for dose reconstruction
- Observed link between radiation and Chronic Lymphocytic Leukemia
- Guidelines for handling of future nuclear events

Remaining/Unresolved Questions

- Thyroid cancer time trends/tumor characteristics
- Risks in those exposed *in utero* or as adults
- Role of iodine deficiency
- Risks of other cancers
- Dose rate effect at low doses
- Non-cancer effects (e.g., cataracts, cardiovascular disease, mental health)

Collaborating Institutions

Ukraine

- Institute of Endocrinology & Metabolism
- Research Center for Radiation Medicine
- Radiation Protection Institute
- National Cancer Registry of Ukraine

Belarus

- Republican Research Center for Radiation Medicine and Human Ecology
- National Cancer Registry of Belarus

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Thank you for your
attention